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The Hermite Electrolytic Process at Poplar.*

BY CHARLES V. BIGGS.

This Paper is a contribution to the data at present available on the subject of the electrolytic production of hypochlorites. It is unnecessary here to recapitulate the history of the various processes for effecting the electrolysis of chlorides so as to produce hypochlorites, or to allude to the purposes for which hypochlorite solutions are adapted. A variety of processes are in existence, and of those which have been reduced to a practical form the best known are the "Hermite," "Electrozone" and the "Oxychloride." Unfortunately, hitherto, the accessible examples of plants actually working on more than an experimental scale have been extremely few; the author only knows of one in this country—namely, the Hermite plant at Poplar. The following data have, therefore, been collected from runs undertaken at this installation in the ordinary course of working for supplying disinfectant to the borough.

The system adopted at Poplar is to mix a certain quantity of fluid in an elevated tank and then to allow this fluid to flow through four double troughs, or cells, placed one above the other so that the liquid descends continuously by gravity. Each trough is divided laterally by a partition, and in each of the two divisions five distinct

* Abstract of a Paper read before the Faraday Society on Tuesday, November 13, 1906.

" elements " (consisting of one positive and two negative plates) are suspended (Fig. 1). The positive plates are of thin platinum wire wound upon slate slabs and the negative plates are of zinc. There are thus four troughs, each containing ten " elements," or 40 cells in all. The liquid enters through the funnel visible towards the top left-hand side of the illustration, passes along the front division of the top trough, back through the division behind, over a weir and into a sub division, from which it is drawn off by the bent glass tube discharging into the second funnel; it passes along the front division, back through the division behind, over the weir into the pocket of the second trough, and so on to the final bent tube, which discharges it into a carboy. A bottle arranged at the right-hand side of the tier of cells (shown) supplies the sodium hydroxide used as a preservative, which flows drop by drop into the carboy as it is filling and serves to neutralise free hypochlorous acid. As the liquid passes through the troughs it is subjected to the action of a current of 15 amperes at 230 volts, being 5·6 volts per cell. During the run the liquid in the carboy is thoroughly stirred by means of an ebonite rod provided with rubber flaps.

The total space occupied by the electrolysing plant (including the tank) is 7 ft. by 7 ft. The capacity of the tank is some 215 gallons. The total head-room is 10 ft. During a run of eight hours 185 gallons of hypochlorite solution at a strength of over four grammes per litre are made. The procedure is as follows :—

The tank is charged by placing in it 100 litres of a saturated solution of sodium chloride and 20 litres of a saturated solution of magnesium chloride. To this is added as much water as is needed to bring the whole quantity up to 840 litres (185 gallons). The liquid flows from a pipe in the bottom of the tank, at the end of which is a ball valve, into a small flushing cistern at the side, in order to obtain an even flow, otherwise as the tank emptied the flow would be slower ; thence through another pipe into the funnel leading to the first row of cells. The second pipe mentioned has a cock for regulating the flow. The rate of flow adopted is $3\frac{1}{3}$ pints (1·9 litres) per minute. This works out at 25 gallons (113·5 litres) per hour, or about 185 gallons (840 litres) in the eight hours. The chemical action appears to be that the NaCl acts as a vehicle for the current; the Mg and Cl ions being given up at the − and + poles, and com-

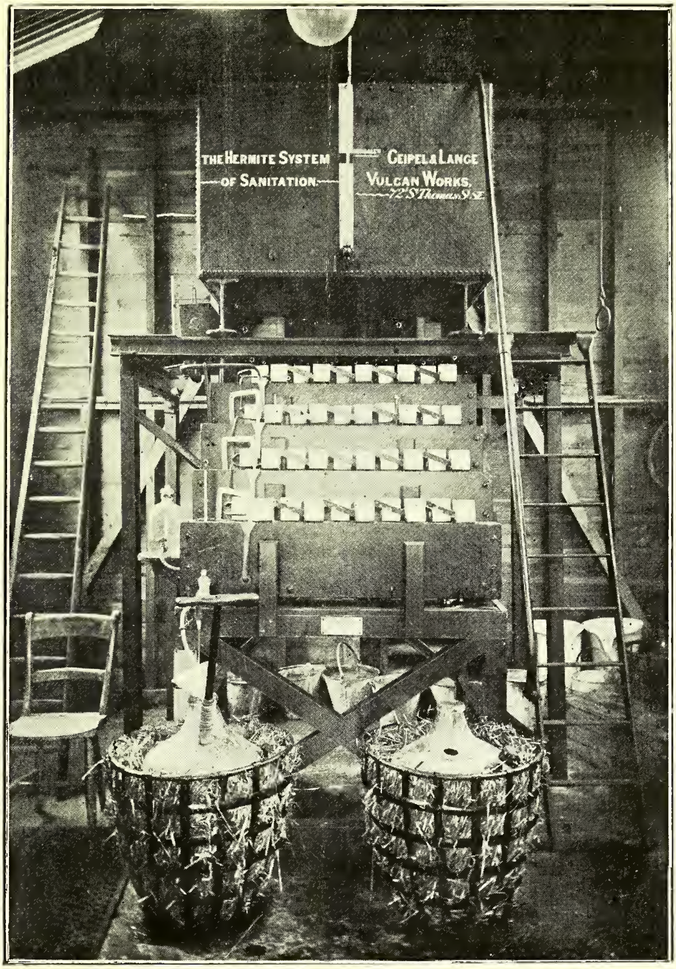

Fig. 1.—General View of the Electrolytic Plant.

bining with H_2O to form $Mg(OH)_2$ and 2HCl, with 2HClO, H_2 being given off. A final re-combination takes place, leaving $MgCl_2$ and $Mg(OCl)_2$ with a little $Mg(OH)_2$ as waste. The results of four runs with different currents are shown below:—

Table I.

Time.	Gr. per litre.	Gr. per B.T.U.	Amps.	Volts	Temperature. Tank.	1st row	Final.	Remarks.
10:0	..	..	12	214	..	..	..	Room temp. 62°. Flow 1·9 litres per min. (3⅓ pints) 113·5 litres per hour.
10:40	3·312	146	..	..	..	..	..	
11:5	3·180	141	12	212	..	..	..	
11:20	..	..	12	212	..	..	..	
11:30	3·117	139	12	212	60	..	80	
11:30	..	..	19	244	60·5	70	80	Room temp. 64°
12:0	..	..	20	246	..	..	94·5	
12:15	..	..	20	245	..	..	95	
12:20	5·3	123	20	244	60·5	70	98	
12:30	5·3	124	20	242	..	..	98	
12:45	5·48	128	20	242	60·5	72	98	
12:55	..	..	17	232	60·5	..	..	Temp. falling owing to reduced current.
1:45	4·818	138	17	232	..	72·5	95·5	
2:0	4·968	142	17	232	..	..	94	
2:15	..	..	18	234	..	..	..	
2:30	4·818	139	17	230	..	..	..	
2:30	..	..	16	224	61	..	..	..
3:0	..	..	16	224	..	..	93	..
3:10	4·676	147	16	230	..	71	93	..
3:30	..	..	16	230	..	70	93	..
3:45	4·818	149	16	228	60	70	94	..

Curves have been plotted from readings taken on these runs. The abscissae in Fig. 2 are merely arbitrary divisions indicating that the liquid has passed through one set (of 10 electrolysers), two sets, three sets, or four sets (final liquid). The ordinates show the strength obtained in grammes per litre. It will be noticed that the increase of 1 gramme per litre in each 10 cells is fully maintained, but has a tendency to fall off after 30 cells.

Figures are also given in the table of the grammes of chlorine per B.T.U. It will be noticed that the highest efficiency is obtained at 16 amperes. The fact that a run at 17 amperes gives worse results than at 16 is not easily accounted for, unless it was due to stable conditions not having been reached on the 17 ampere run.

The high temperatures at which some of the samples have been made are interesting, in view of the widespread belief that the hypochlorite solution deteriorates rapidly if made under such con-

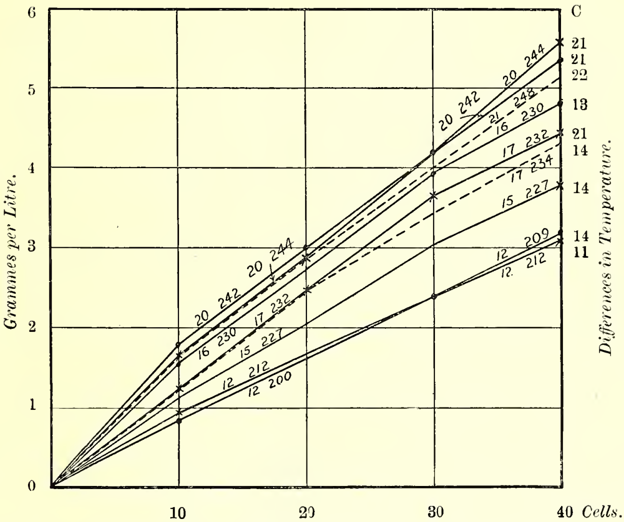

Fig. 2.—Curves showing Rise in Value of Solution as it passes through each Set of Ten Cells.

ditions. Samples were taken from solutions made and bottled during the warm weather of last summer with the following results :—

Table II.

Temperature difference between Tank and final Liquid.	Temperature of Final Liquid when made.	Loss in Grammes per Litre.	Time between Making and Re-testing.
(1) 15 °C. 27°F.	40°C. 104°F.	0·5	6 weeks.
(2) 14·5°C. 26°F.	40°C. 104°F.	0·2	4 ,,
(3) 15·6°C. 27°F.	40°C. 104°F.	0·1	6 ,,
(4) 14·5°C. 26°F.	34°C. 93°F.	0·1	6 ,,

For example, a specimen made at a temperature of 40°C. and a strength of 5·4 grammes per litre, was tested three hours later to see if immediate depreciation took place in hot liquids, but found to be the same, practically. The test gave 5·3 for the whole carboy, which contained more 5·3 than 5·4 liquid.

The principal conclusions to be drawn from the working of this plant appear to be the following:—

(*a*) The manufacture of hypochlorite solutions can be carried on by a process which is practically automatic. (*b*) For an output of 200 gallons per eight hours at 4 grammes per litre the capital cost, including buildings and fittings, should not exceed £500. (*c*) Where continuous current is available the series system of electrolysing is the most suitable. Where alternating current only is to be had, and a motor-generator must be installed, fewer cells may be employed. In the Poplar plant about 1 gramme per litre is added for every 10 cells. (*d*) That a warm climate would not affect the manufacture at any rate of magnesium hypochlorite.

In conclusion, the author wishes to acknowledge his indebtness to Dr. Alexander, the medical officer of health for Poplar, for giving him every facility for inspecting the plant. The improvements suggested by Dr. Alexander, which have been introduced in the plant in question, are numerous, and it is largely due to them that the running has become the simple process described.

The following figures are given in an appendix as the cost for an ordinary run of eight hours, producing 185 gallons of the fluid :—

	s.	d.
(NaCl) salt	1	6
Magnesium chloride	1	0
Electricity	2	6
Attendance and labour, say	4	0
	9	0
Interest on £500 at 4½ per cent., say 2s. per run......	2	0—11s.

Reductions in the price of salt could be obtained by buying in bulk and if the disinfectant plant were made an adjunct to the borough electrical generating station the cost of attendance could be reduced. Probably, including bottling and depreciation of plant, ¾d. per gallon is a fair estimate for the smaller sizes of plant.

DISCUSSION.

Mr. J. B. C. KERSHAW (communicated) considered that electrolytic hypochlorite was unlikely to replace bleaching powder at present prices. He criticised the efficiency of the Hermite plant at Poplar.

Dr. R. S. HUTTON hoped that further information regarding the electrodes and other important details of the Poplar plant and also further data regarding cost and efficiency would be forthcoming. He drew attention to the theoretical work that had been done on the Continent. Replying to Mr. Kershaw's strictures, efficiency depended on concentration. At Poplar low concentrations were used, so the efficiency was relatively low.

Dr. ALEXANDER, the medical officer of health of Poplar, stated he was not a chemist nor an electrician. He had no financial interest in the Hermite process, but had simply taken up the subject from a scientific point of view. He had not benefited in any way by it, and did not expect to do so. He had worked for the love of the matter, and he had no axe to grind. Were we living in the days of Galileo? He was astonished to think that in the nineteenth century every possible obstacle had been placed in his way through certain articles in the Press advising his Council not to listen to him as the process had been a failure in the past, and could not possibly be of any use; it would be waste of public money and was simply a fad of the medical officer. If the process had been of any use it would have come into operation before. However, he had had the matter in his mind for many years since the publication of the report of the *Lancet* Commission, and had worked at the subject for nearly two years, and the working of the apparatus in Poplar was a complete success—it had come to stay—and had gone quite beyond his expectations. No doubt the failure of the past had been due to the want of stability of the fluid, but this had now been got over, as is seen by stability Table II. of the Paper, and the samples, be it remembered, were some of the first made before the use of the stirrers. It was prophesied in the Press that the formation of the oxychloride would choke or block the zinc electrodes, and that scrapers had been used in the past; but he would speak on this matter later on as to how the oxychlorides are dealt with. It was also stated that chloride of lime would be better to use. Well, he wanted to know how could this substance be bottled and given out to the public? One would have to mix it with water to dissolve out the calcium hypochlorite, and as the commercial powder contains 30 to 38 per cent. of available chlorine the waste lime would have to be disposed of, and all this meant labour. Moreover, chlorinated lime solutions will destroy fabrics sooner than hypochlorites of soda or magnesia. As to the cost of making the fluid in Poplar the apparatus had been running since the end of January, a period of 10 months, during which time there had

been required 2,288 units of electrical energy at 1½d. per unit, amounting to £15, not quite 4 tons of salt at 24s. a ton, amounting to £4. 16s., and not quite 2 tons of chloride of magnesium at £3. 17s. 6d. per ton, amounting to £7. 15s. : the cost of the caustic soda was about £2. 10s., and water £2, making a total of £32, and this sum included material in hand. This expenditure did not include the labour, which really is less than in the old days when carbolic acid was bottled and bags were filled with carbolic powder and distributed to the public. He would speak later on with respect to this labour question. Now, for the sum of £32, including material in hand, the Public Health department had been supplied with disinfectant fluid against an expenditure of £313 for the year 1905 ; and, moreover, in the Works department the roads, with the market places in the parish of Bromley, had been watered with the fluid, and now the sick asylums at Poplar and Bromley were being supplied, also the workhouse and all institutions inside and outside the borough belonging to the guardians. Surely this was success, whatever the detractors of the process might say, and all this for the sum of £32. With respect to the watering of the roads and market places, the water carts in Poplar had a capacity of 400 gallons and on the top of each cart had been fixed a small tank to hold 15 gallons of the electrolysed fluid. Five gallons of this fluid were added to each 400 gallons of water, giving a strength of 0·05 gramme of chlorine per litre. He had based this strength on a statement of Dr. Rideal that " in experiments conducted by Prof. Robinson, Dr. Kanthack and myself, a bad effluent was treated with one or two parts of chlorine per 100,000 with very satisfactory results as regards bacteria." Now, as to the working of the apparatus, one man only is required, and he not a skilled one, merely an ordinary intelligent individual at 35s. per week. He attends to the charging and working of the apparatus and the testing of the fluid, and keeps a log of each day's work and distribution. It is true there is another man at the depot with wages of 30s. per week. This man is engaged in bottling and delivering the fluid for distribution, and he is also quite capable of looking after the apparatus. Formerly, in the fluid and carbolic acid powder days, during the busy time six or seven men were at work. The object of the medical officer was to make the working of the apparatus of such a nature as to be simple and automatic, and not to require the constant attention of a skilled person who would receive a high salary and men to do the labour work, which would increase the cost of the output. The objects aimed at were as follows :—(1) To see at a glance whether the apparatus is working properly. This is accomplished by a gauge glass in front of the large tank and another gauge glass on the little supply tank, the first to show the quantity of salt liquor capable of being acted upon, and the second to show if the liquor is running properly into and out of the small supply tank, as the chloride of magnesium contains impurities

which are likely to block up the valve of the small cistern and the taps leading to and from the same. A thermometer is kept in the small supply tank to see the temperature of the salt liquor, and another thermometer is placed at the outgo of the last electrolyser; the difference of the temperature gives the rise in temperature due to the electrolysis, and which is found, when the apparatus is working satisfactorily, to be under 30°F. The small tank is necessary to keep a constant flow of the fluid into the electrolysers. When first the apparatus was erected the fluid used to become unduly hot on account of the flow slowing down through the diminution of the head of water in the large tank. This tank had ultimately to be raised on to girders, and a small supply tank fixed at a lower level. (2) The liquor to be electrolysed in the large tank had to be stirred from time to time to keep the mixture of an equal gravity throughout, more especially as for obvious reasons a certain quantity of a solution of sodium hydroxide is added. To keep the liquor stirred a large broad drilled plate of galvanised iron is used, one end of which acts as the fulcrum when the other is lifted up by means of a chain leading over pulleys to the ground so that the attendant has only now and again to pull the chain to lift the plate up and down instead of running up and down the ladder and stirring the liquid with a rod. (3) It is necessary to govern the electric current, which is taken direct from the mains, on account of the density of the salt mixture to be acted upon varying from time to time owing to temperature changes and consequent changes in conductivity. This difficulty is got over by the current regulator. (4) To prevent shocks and waste of fluid whilst changing the carboys, a special glass tap has been made. (5) To prevent loss of available chlorine the solution of sodium hydroxide drips into a specially blown carboy at the same time as the fluid is running into it, and the two fluids are mixed with a stirrer inserted through an aperature in the neck of the carboy, and when the carboy is full a final mixing for about two minutes is given by means of a stirrer fixed to gear wheels. Before the ebonite stirrers with rubber flaps were made, full carboys and half carboys had to be shaken rapidly for 10 minutes, and this not always with the best results as to bringing about the desired stability, for when sodium hydroxide is added the precipitate falls to the bottom, and it is necessary to render the solution milky throughout. Dr. Alexander stated that no doubt the instability of the fluid was due to the salt in the fluid. M. Hermite made a fluid for medical purposes called "Hermitine," which had the salt taken out of it by a secret process, and thereby the fluid was rendered practically absolutely stable, and so much so that it was not kept in amber-coloured bottles; but for disinfecting purposes the fluid made at Poplar was, of course, stable enough. The plant at Netley was still running satisfactorily, but in that case a stable form of hypochlorite was not required. (6) So far as oxychlorides are concerned, the apparatus

in 10 months had only been taken to pieces and cleaned twice. Every day, after working, the electrolysers are emptied by means of the mud holes by removing the rubber plugs, and the fluid which is run out is kept to recharge the electrolysers. The electrolysers, after being emptied, are washed out by means of a hose and then until the next working are kept filled with water, which softens any deposit formed upon the electrodes, and before starting work the electrolysers are emptied and washed out again, a matter which takes up a few minutes every day before and after each working. Dr. Alexander mentioned that he had seen an exceedingly simple apparatus in M. Hermite's factory at Rolleville which makes a solution of hypochlorite of magnesia having 10 grammes of chlorine per litre, and it was a very easy matter on the same lines to make it at 50 grammes per litre, but he, of course, could not give details to the society as the apparatus was shown to him in confidence. Dr. Alexander thanked Mr. Bowden, the chief electrical engineer to his borough, for the kindly words of cheer which he gave him during the exceedingly trying time when he was endeavouring to make the apparatus work simply and automatically, and to render the fluid stable by simple means, so that he could justify himself in having recommended his Council to expend public money for such a venture. Dr. Alexander finished by stating that whatever the detractors of the process might say, there was no doubt in his mind the process had now come to stay, as it was obvious in these days of cheap electricity nothing could be better for a sanitary authority than to possess a simple automatic apparatus which has a tap to be turned on at any moment to deliver a cheap and efficient disinfectant composed of oxygen and chlorine.

The members were invited to inspect the apparatus.

Dr. S. RIDEAL was of opinion that the convenience of being able to make hypochlorite on the spot as required for disinfecting purposes rendered it far more suitable than bleaching powder. The dust nuisance caused by motor cars rendered the use of a sterilising fluid for street watering a necessity.

Mr. L. A. SMART remarked on the value of such electrochemical processes to borough engineers if they could be arranged to run so as to increase the load factor of the power station.

Mr. W. DEFRIES pointed out that although the price of raw materials would probably not decrease, that of power tended to dimish, so electrolytic hypochlorite would in time compete favourably, even as regards price, with chloride of lime.

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